Memorandum

Honeywell Technology Solutions, Inc.
Lanham, Maryland

Date: August 1, 2008
To: Howard Donovan
From: Jim Long
Subject: Survey Report for NGSLR - MOBLAS 7 Intercomparison

Introduction:

This report distributes the final survey data and ground calibration data necessary for the intercomparison of NGSLR and MOBLAS 7 at the NASA Goddard Geophysical and Astronomical Observatory (GGAO), Greenbelt, Maryland

Field Survey Data Acquisiton:

The majority of the survey data was collected during November 2007, by the undersigned and Troy Carpenter, as part of a comprehensive survey project to determine the local-ties for the co-located space geodesy systems at GGAO. Additional survey data was collected in January and April 2008.

The survey strategy was developed, utilizing the network of existing ground control monuments, for a goal of 1 millimeter (mm) accuracy in each coordinate direction and conducted with the high-precision methods and equipment to achieve this goal.

Leica electronic theodolites (T3000 and T2002; angular accuracy standard deviation of 0.5 seconds) were used to measure horizontal and vertical angles. Lecia electronic distance measurement (EDM) instruments (DI2000 and DI2002; accuracy standard deviation of 1 mm + 1 ppm) were used to measure slope distances. Prior to the start of the survey measurements, the calibration constants for the EDM instruments were verified on a 3-station baseline, temporarily established at GGAO. The distance measurement targets were corner cube prisms, previously calibrated at the NGS Corbin facility. Leica electronic level instruments (NA2000 and NA3003; accuracy standard deviation of 1.5 mm and 1.2 mm, respectively) were used for the differential level measurements. Trimble 4000SSE receivers with Trimble choke ring antennas were used for GPS observations (horizontal accuracy standard deviation of 5mm + 1 ppm; vertical accuracy standard deviation of 10 mm + 1 ppm).

For both MOBLAS 7 and NGSLR, the vertical axis of rotation was determined by setting an assembly of a 2-dimensional translation stage and a survey target on the top of the mount, with the system telescope level with the horizon. The horizontal position of the survey target was adjusted so as to remain stationary when sighted through the theodolite telescope, as the SLR mount was rotated about the vertical rotation axis.

For MOBLAS 7, the offset to the horizontal axis of rotation was determined by running differential levels to the top side of spotting telescope eyepiece ,located on the horizontal (elevation) rotation axis of the mount, and then repeated with the mount telescope plunged 180 degrees. The diameter of the telescope eyepiece was measured with calipers. All measurements were repeated, as a check.

For NGSLR, the offset to the horizontal axis of rotation was determined by using diffential levels to a non-moveable point on top of the encoder housing. The cover to the encoder housing was removed and the vertical distance to point on the "top"of the encoder hub was measured with a pocket tape. The mount telescope was plunged 180 degree and the vertical distance to the same point (now the "bottom") of the encoder hub was measured. The mean of the two vertical distance measurements represents the horizontal rotation axis. This procedure was repeated with a different observer and a different pocket tape, as a check.

The horizontal angle and slope distance between MOBLAS 7 and NGSLR was directly measured from both ends of the line.

Survey Data Processing and Analysis:

The observed field survey data was reduced and used to develop a data file for input to the HAVAGO least-squares adjustment software. The geocentric coordinates for survey control monument 'CDP Station 7105'(DOMES No.: 40451M105) were constrained, at the 0.001 meter level, to the values as listed in the ITRF 2000 (epoch 1997.0) solution table (file: ITRF2000_SLR.SSC). The HAVAGO data input file was configured to translate the resulting adjusted coordinates to SLR re-scaled ITRF 2005 (epoch 2000.0) reference frame , using translation parameters calculated from the coordinate differences for 'CDP Station 7105', based on the listed values in the ITRF 2005 (epoch 2000.0) SLR re-scaled solution table (file: ITRF2005_SLR-rescaled.SSC).

Station Positions:

The SLR observation reference monument for MOBLAS 7 is 'CDP Station 7105' and the SLR mount is set up over the reference monument. The SLR observation reference monument for NGSLR is 'CDP Station 7125' (DOMES No.: 40451M114) and the system is offset approximately 2.8 meters to the west of the reference monument. The adjusted coordinates for these observation reference monuments are listed below. The geodetic coordinates are referenced to the GRS80 ellipsoid with the constants: A=6378137.0 and 1/f = 298.2572221.

GEODETIC COORDINATES - ITRF2000 (1997.0)

Station	Latitude (d,m,s)	Longitude (d,m,s)	Height(m)
7105	39° 01′ 14.17743″ N	76° 49′ 39.69785″ W	19.194
		(283° 10′ 20.30215″ E)	
7125	39° 01′ 12.96880″ N	76° 49′ 38.80938″ W	18.506
		(283° 10′ 21.19062″ E)	

GEOCENTRIC COORDINATES – ITRF2000 (1997.0)

Station	X (m)	Y (m)	Z (m)
7105	1130719.632	-4831350.577	3994106.539
7125	1130745.668	-4831368.035	3994077.149

GEODETIC COORDINATES - ITRF2005 (2000.0) SLR-rescaled

Station	Latitude (d,m,s)	Longitude (d,m,s)	Height(m)
7105	39° 01′ 14.17780″ N	76° 49′ 39.69971″ W	19.190
		(283° 10′ 20.30029″ E)	
7125	39° 01′ 12.96916″ N	76° 49′ 38.81124″ W	18.502
		(283° 10′ 21.18876″ E)	

GEOCENTRIC COORDINATES – ITRF2005 (2000.0) SLR-rescaled

Station	X (m)	Y (m)	Z (m)
7105	1130719.586	-4831350.577	3994106.545
7125	1130745.622	-4831368.035	3994077.155

SLR System Eccentricities:

The following system eccentricity values are computed as part of the HAVAGO output from the adjusted positions for the SLR system reference points and show the differential coordinates from the appropriate SLR observation reference monument.

MOBLAS 7 ECCENTRICITIES FROM CDP STATION 7105

ΔNorth (m)	ΔEast (m)	ΔUp (m)
-0.007	-0.034	+3.138

ΔX (m)	ΔY (m)	ΔZ (m)
+0.524	-2.385	+1.970

NGSLR ECCENTRICITIES FROM CDP STATION 7125

ΔNorth (m)	ΔEast (m)	ΔUp (m)
-0.082	-2.814	+3.696

ΔX (m)	ΔY (m)	ΔZ (m)
-2.074	-3.488	+2.264

Differential Coordinates for SLR Intercomparison:

The following differential coordinates values represent the 3-dimensional vector from the MOBLAS 7 observation reference monument to the NGSLR observation reference monument ('CDP Station 7105' to 'CDP Station 7125') and the 3-dimensional vector from the MOBLAS 7 reference point to the NGSLR reference point. These values are computed from the adjusted positions in the HAVAGO output.

DIFFERENTIAL COORDINATES FROM 7105 TO 7125

ΔNorth (m)	ΔEast (m)	ΔUp (m)
-37.272	+21.373	-0.688

ΔX (m)	ΔY (m)	ΔZ (m)
+26.036	-17.458	-29.390

DIFFERENTIAL COORDINATES FROM MOBLAS 7 TO NGSLR

ΔNorth (m)	ΔEast (m)	ΔUp (m)
-37.346	+18.593	-0.128

ΔX (m)	ΔY (m)	ΔZ (m)
+23.439	-18.561	-29.096

SLR Calibration Data:

The following is the calibration data for MOBLAS 7 and NGLSR. Calibration Pier C is the primary calibration target for MOBLAS 7.

MOBLAS 7 CALIBRATION DATA

TARGET	RANGE (m)	AZIMUTH	ELEVATION ANGLE
Cal Pier A	106.674	64.9356°	-3.1322°
Cal Pier B	174.835	95.5138°	-1.7361°
Cal Pier C	170.527	105.0118°	-1.6614°

NGSLR CALIBRATION DATA

TARGET	RANGE (m)	AZIMUTH	ELEVATION ANGLE
Cal Pier A	113.584	43.3586°	-2.8768°
Cal Pier B	156.793	82.4604°	-1.8890°
Cal Pier C	146.284	92.6650°	-1.8866°

Conclusions and Remarks:

In order to verify the HAVAGO results, the survey data was used to develop an input file for the Microsearch GeoLab3 least-squares adjustment software and the results were compared and found to be within the 0.001 meter standard error of the adjustments.

Please note that the reported value of +3.138 meter for the 'Up' eccentricity for MOBLAS 7 has increased by 2 mm from the +3.136 meter value shown in the "Preliminary Report of Geodetic Site Survey" issued in January 2008. Upon identifying a discrepancy in the 'Up" eccentricity from previous report values and conducting further analysis, it was determined that the differential level observations between 'CDP Station 7105' and 'North GEOS Pier' were greater by about 2 mm when compared with the results from level observations during previous surveys at GGAO, going back to the year 1990. The differential level observations between 'CDP Station 7105' and 'North GEOS Pier' were repeated two times, on two different days in March 2008 and all observations

were included in the adjustment. The relative difference in height between 'North GEOS Pier' and MOBLAS 7 remained unchanged.

If there are any questions concerning this survey or the calibration data, please contact me at (410) 964-7435.

Jim Long,
Geodetic Surveyor
SLR Development Projects
Near Earth Network Services
Honeywell Technology Solutions Inc.